Status of insectivorous plants in northeast India

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Introduction

There are approximately 700 identified species of carnivorous plants placed in 15 genera of nine families of dicotyledonous plants (Albert *et al.* 1992; Ellison & Gotellli 2001; Fleischmann 2012; Rice 2006) (Table 1).

In India, a total of five genera of carnivorous plants are reported with 44 species; *viz*. *Utricularia* (38 species), *Drosera* (3), *Nepenthes* (1), *Pinguicula* (1), and *Aldrovanda* (1) (Santapau & Henry 1976; Anonymous 1988; Singh & Sanjappa 2011; Zaman *et al*. 2011; Kamble *et al*. 2012). Interestingly, northeastern India is the home of all five insectivorous genera, namely *Nepenthes* (commonly known as tropical pitcher plant), *Drosera* (sundew), *Utricularia* (bladderwort), *Aldrovanda* (waterwheel plant), and *Pinguicula* (butterwort) with a total of 21 species. The area also hosts the "ancestral false carnivorous" plant *Plumbago zelayanica*, often known as murderous plant.

Climate

Lowland to mid-altitude areas are characterized by subtropical climate (Table 2) with maximum temperatures and maximum precipitation (monsoon) in summer, *i.e.*, May to September (in some places the highest temperatures are reached already in April), and average temperatures usually not dropping below 0°C in winter. As usual average temperatures decrease with increasing elevation, and in highlands, a mountain/alpine climate prevails. In Sikkim and Arunachal Pradesh, the tree line ranges from 5500 m in the north to 4000 m in the south, and the snow line ranges from 6100 m in the north to 4900 m in the south.

Chorology

The extreme northeast of India (Sikkim, Darjeeling – the northern part of West Bengal, Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Tripura, Mizoram) is one of the most floristically most diverse places in Asia as it is located in the contact zone between the temperate flora from high elevations (Himalaya), the tropical flora from lowland peninsular India and Burma, and the subtropical flora from Yunnan, China. To the west it shares a border with Nepal, to the north with Bhutan, and China (Tibet), to the east with Burma (Myanmar) and to the south with Bangladesh. Covering less than 275,000 km^2, it is composed of six different floristic provinces in four

Table 1. Comparison of carnivorous plant diversity (world/India/NE India). Data derived from the Carnivorous Plant Database. http://www.omnisterra.com/bot/cp_home.cgi, accessed 24 Feb. 2014.

Order	Family	Genus	Number of described species		
			World	India	NE India
Oxalidales	Cephalotaceae	*Cephalotus*	1		
Nepenthales (Caryophyllales s. lat.)	Droseraceae	*Drosera*	168	3	2
		Aldrovanda	1	1	1
		Dionaea	1		
	Drosophyllaceae	*Drosophyllum*	1		
	Nepenthaceae	*Nepenthes*	127	1	1
	Dioncophyllaceae	*Triphyophyllum*	1		
Ericales	Sarraceniaceae	*Darlingtonia*	1		
		Heliamphora	20		
		Sarracenia	8		
	Roridulaceae	*Roridula*	2		
Scrophulariales (Lamiales)	Byblidaceae	*Byblis*	7		
	Lentibulariaceae	*Pinguicula*	94	1	1
		Genlisea	27		
		Utricularia	234	38	16
Total			693	44	21

Regions according to Takhtajan's (1986) scheme: the Northern Burmese, Eastern Himalayan, and Khasi-Maipur Provinces belonging to the Eastern Asiatic Region, the Tibetan Province belonging to the Irano-Turanian Region, the Bengal Province belonging to the Indian Region, and the Southern Burmese Province belonging to the Indochinese Region. Any area of comparable size and latitudinal extension (between 22°N and 30°N) in the New World or in Africa would cover at the most three Provinces in at the most two Regions. This extraordinary diversity is mainly due to the unique topographical profile, ranging from almost sea level in the Brahmaputra valley to 8598 m elevation (Kangchenjunga) at the Nepal border.

Pinguicula alpina (arctic + alpine + Himalayan) belongs to the temperate element. The paleotropical element is represented by *Nepenthes khasiana*. Its entire range is contained in the area of concern and is located north of the Tropic of Cancer, *i.e.*, this is the only species in the genus *Nepenthes* naturally occurring outside the tropics. *Drosera peltata* is widespread in eastern Asia, Australia, and Oceania (Gibson *et al.* 2012, as *D. lunata*). It is the only tuber forming sundew to reach beyond the Australian diversification center of this group. *Drosera burmannii* is widespread in the Australasian tropics. While it is disputed whether its only record from Africa (Sierra Leone) is native there, another, closely related species (*D. sessilifolia*) is its neotropical counterpart. The tropical bladderworts in the area are the terrestrial *Utricularia hirta*, *U. pubescens*, *U. caerulea*, *U. bifida*, *U. recta* (syn. *U. scandens* subsp. *firmula*), *U. foveolata*, *U. subulata*, and the aquatic *U. aurea*, *U. stellaris*, and *U. inflexa*, all of which are more or less widespread in tropical eastern Asia

Table 2. Climate data of representative towns in NE India (classification according to Köppen & Geiger 1930-1939, data from Wikipedia http://en.wikipedia.org/).

Location; State; Elevation	Climate Class	Precipitation	Temperature
		Annual /Monthly	Summer / Winter
Aizawl; Mizoram; 1132 m	Humid Subtropical (Cwa)	2200 mm / 6 mm (Jan.) - 305 mm (Aug.)	18-27°C (max.: Apr.) / 25-11°C
Agartala; Tripura; 13 m		2200 mm / 8 mm (Dec.) - 455 mm (Jun.)	24- 34°C (max.: Apr.) / 33-10°C
Guwahati; Assam; 55 m		1700 mm / 7 mm (Dec.) - 345 mm (Jul.)	22-32°C / 30-10°C
Imphal; Manipur; 790 m		1400 mm / 12 mm (Jan.) - 225 mm (Jun.)	15-33°C / 30-11°C
Kohima; Nagaland; 1450 m		1800 mm / 8 mm (Dec.) - 370 mm (Jul.)	17-25°C / 23-5°C
Shillong; Meghalaya; 1500 m	Subtropical-Highland (Cwb)	2200 mm / 9 mm (Dec.) - 470 mm (Jun.)	15-24°C / 23-4°C
Itanagar; Arunachal Pradesh; 750 m		2300 mm / 15 mm (Nov.) - 510 mm (Jul.)	18-34°C / 18-8°C
Darjeeling; N West Bengal; 2050 m		3000 mm / 7 mm (Dec.) - 780 mm (Jul.)	11-20°C / 14-2°C
Gangtok; Sikkim; 1700 m		3600 mm / 23 mm (Dec.) - 650 mm (Jul.)	13-22°C / 18-4°C

and many spread to tropical Africa and Australia, while only *U. pubescens* and *U. subulata* are also found in the Americas.

Utricularia. gibba and *Aldrovanda vesiculosa* represent azonal aquatics not closely tied to any climatic vegetation zone.

An exceptionally large number of species of the subtropical to tropical section *Phyllaria* of *Utricularia* (*U. furcellata*, *U. christopheri*, *U. brachiata*, *U. striatula*, *U. multicaulis*) are native or even endemic to this area. *Utricularia kumaonensis*, *U. salwinensis*, and *U. forrestii*, likewise members of this section, are known from the Salween-Irrawaddy divide in westernmost Yunnan, China/northernmost Burma, *i.e.*, within some 200 km to the east of the area treated here. As all three species do also occur in the immediate vicinity to the north (Nepal, Bhutan, Tibet), it is quite probable that they occur in Himalayan northeastern India although no specimens have apparently been collected from here so far.

Other species presently not recorded from the area but known from surrounding territories are:
Drosera indica (paleotropical, including. West Bengal, *cf.* Basak 1975, China [Yunnan], Burma);
Utricularia capillacea (syn. *U. scandens*, paleotropical, including. Bihar, Nepal, China [Tibet, Yunnan], Burma, Bangladesh);
U. graminifolia (tropical East Asian, including, China [Yunnan], Burma);
U. uliginosa (tropical East Asian, including, China [Yunnan], Burma);
U. australis (azonal, widespread in the Old World, including, Nepal, Bhutan, China [Tibet, Yunnan], Burma);
U. minor (circumboreal, including, Nepal, Bhutan, China [Tibet, Yunnan], Burma).

The majority (some 20) of the remaining Indian bladderwort species not known from the extreme northeast are members of *U.* section *Oligocista* and are more or less restricted to the Deccan peninsula, predominantly in the Western Ghats (Janarthanam & Henry 1992; Taylor 1989).

Conservation Status

1. *Nepenthes khasiana* Hook. f.: Popularly known as tropical pitcher plants or monkey cups, *Nepenthes khasiana* belongs to the monotypic family Nepenthaceae with 127 natural and hybrid species across the world (Jebb & Cheek 1997; Wikipedia 2013). It is the only native Indian species of insectivorous plant which is an endemic of Garo, Khasi, and Jaintia hills of Meghalaya. It greatly varies in its habit ranging from prostrate to scandent or rarely erect herbs, undershrubs, or shrubs. The plants are mostly associated with the natural vegetation of very humid climates.
Distribution in northeast India: Endemic to Meghalaya**:** East Khasi hills, West Khasi hills, Jaintia hills, south Garo hills, west Garo hills (Joseph & Joseph 1986; Venugopal & Devi 2003; Singh *et al.* 2011).
Present status: Habitat destruction is one of the main threats especially in Jaintia and Garo hills, where the coal mining plays a significance role in the decline of its natural population (Prasad & Jeeva 2009; Singh *et al.* 2011). Excessive collection, developmental activities, deforestation, fragmentation, increasing production of waste and pollutants, forest fire, *jhum* cultivation, and poor seed germination ability of the plant are also some of the causes of declining populations (Bordoloi 1977; Jain & Sastry 1980; Rathore *et al.* 1991; Mandal & Mukherjee 2011). It is classified as 'Endangered' (EN) and is incorporated in the Appendix I of CITES and Negative List of Exports of the Government of India (Ziemer 2010; Mandal & Mukherjee 2011). The species is restricted only in some pockets of Meghalaya.

2. *Drosera* L.: One of the largest genera of carnivorous plants (commonly known as sundews) with more than 160 species belonging to the family Droseraceae (Rice 2006; Jayaram & Prasad 2006).

2.1. *Drosera burmannii* Vahl: One of the most common insectivorous species among Indian carnivorous plants and found in tropical and subtropical parts of the country. This annual species possess spatulate leaves and forms rosettes which spans up to 2.5 cm. This species has important medicinal properties as it contains several medicinally active compounds including quinones (plumbagin), hydroplumbagin glucoside, flavonoids (kaempferol, myricetin, quercetin, and hyperoside), rossoliside (7-methyl-hydrojuglone-4-glucoside), and has been used for several disorders (Raju & Christina 2013).
Distribution: Arunachal Pradesh, Assam, Meghalaya, Sikkim, Tripura (Majumdar *et al.* 2011).
Present status: Least concerned (LC) ver.3.1, IUCN, 2011 (Zhuang 2011a). The species has a wide range of distribution and no current threats are reported for Indian populations.

2.2 *Drosera peltata* Thunb. (syn. *Drosera lunata* Buch.-Ham. ex DC.)**:** This is a climbing or scrambling sundew species commonly called shield sundew. The species possesses cauline or peltate cauline leaves and can be easily identified in the field with its aerial parts growing from 5 to 15 cm in height. The species is a promising medicinal plant species due to its antimicrobial activity particularly against the oral bacteria (Didry *et al.* 1998).
Distribution in northeast India: Meghalaya (Jantia hills, east and west Khasi hills), (Venugopal *et al.* 2007).

Present status: The species is somewhat rare and known only in some areas of Meghalaya growing on expose rocks in association with mosses.

3. *Utricularia* L.: Another large genus of carnivorous plants with more than 230 species, which belongs to the family Lentibulariaceae (Parnell 2005; Fleischmann 2012) and commonly grows in floating as well as marshy lands. Unlike the other carnivorous plants discussed here, *Utricularia* often lives in aquatic conditions. A total of 16 species are found in northeastern India.

3.1. *Utricularia aurea* Lour.: Commonly known as golden bladderwort and is common in marshy and wet land of the area. Another important plant with compounds showing anti-tumor activity have been reported (Choosawad *et al*. 2005).
Distribution in northeast India: Assam (Sharma 2012, as *Utricularia flexuosa* Vahl.), Tripura (Bhowmik & Datta 2013).
Present status: The IUCN, 2103 listed the species under Least Concern (LC) ver 3.1 (IUCN 2013).

3.2. *Utricularia bifida* L.: The small and annual plants are found growing in marshy land as well as damp soil and commonly known as bifid bladderwort.
Distribution in northeast India: Assam, Meghalaya, Tripura (Bhowmik & Datta 2012a, 2013).
Present status: No major threats has been reported regionally as well as globally hence it been identified and is therefore listed as Least Concern (LC) 3.1. (Zhuang 2011b).

3.3. *Utricularia brachiata* Oliv.: Discovered by J.D. Hooker from Sikkim Himalaya and partially described by D. Oliver in 1859. The plants are very small, inconspicuous, with delicate, reniform leaves and grow as epiphyte intermixed with bryophytes on tree trunks (Compton 1909).
Distribution in northeast India: Arunachal Pradesh, Sikkim- Kyongnosla Alpine Sanctuary (Compton 1909; Taylor 1989).
Present status: In northeast India the species is very rare and restricted only to the upper hills of eastern Himalaya with in rather small populations.

3.4. *Utricularia caerulea* L.: Small to medium sized species commonly known as blue bladderwort (Kato *et al*. 2006; Kamble *et al*. 2012).
Distribution in northeast India: Meghalaya, Tripura (Bhowmik & Datta 2012b).
Present status: Very common in distribution and found from Madagascar to Japan and Australia through India and Malaysia (Kamble *et al*. 2012).

3.5. *Utricularia christopheri* P.Taylor: Perennial in nature.
Distribution in northeast India: Confined to East Himalayan region including Nepal; Sikkim-Changu, Lachen (Taylor 1989).
Present status: Grows in very high elevation in Sikkim Himalaya and Nepal with very limited distribution (Taylor 1989).

3.6. *Utricularia gibba* L.: A perennial aquatic herb commonly known as humped bladderwort. May be floating, growing submerged, or exposed on wet soil. One of the most common species among *Utricularia* (Taylor 1989).
Distribution in northeast India: Meghalaya (as *U. khasiana* Joseph & Mani), Tripura (as *U. gibba* subsp. *exoleta* (R. Br.) P.Taylor) (Deb 1983; Bhowmik & Datta 2013), Assam and Manipur (as *U.*

exoleta R. Br.) (Dixit & Bera 2012; Hazarika & Borthakur 2012).
Present status: Least Concern (LC) ver 3.1 (Anitha 2011).

3.7. *Utricularia foveolata* Edgew.: A small short-lived herb growing in shallow water or wet soil in seasonally wet grassland or occasionally as a weed in ricefields.
Distribution in northeast India: Meghalaya: Elephant Falls as *U. baouleensis* A. Chev. (Subramanyam & Kamble 1968).
Present status: Very rare in occurrence as it has been reported only once from Elephant Falls of Meghalaya in 1968 and no further reports are available from this area. Hence more detailed surveys are necessary to reveal its current status in India.

3.8. *Utricularia furcellata* Oliv.: Grows on moist logs or rocks along with mosses and form 3-5 mm wide rosettes.
Distribution in northeast India: Assam, Meghalaya, Mizoram, West Bengal (Suksathan & Parnell 2010; Chew & Haron 2011; Panday *et al.* 2013; Yee *et al.* 2012).
Present status: The status is yet to be worked out; however, recently it has been considered as rare in Mizoram (Panday *et al.* 2013).

3.9. *Utricularia hirta* J.G.Klein ex Link.: A small perennial, terrestrial insectivorous plant, native of Southeast Asia, and always growing in damp open places.
Distribution in northeast India: Meghalaya (Joseph & Mani 1982, as *U. tayloriana* J.Joseph & J.Mani), Tripura (Joseph & Mani 1982; Natarajan *et al.* 2008).
Present status: Least Concern (LC) ver 3.1 (Anitha 2011).

3.10. *Utricularia multicaulis* Oliv.: Very small growing annually and native of Southeast Asia.
Distribution in northeast India: Sikkim (Oliver 1859).
Present status: Discovered from Sikkim by Oliver (1859). Though the species has also been reported from China, in India, the plants seem extremely rare, as further reports are scanty.

3.11. *Utricularia striatula* Sm.: Commonly known as striped bladderwort is a small insectivorous herb which is growing on wet rock or even on tree trunks.
Distribution in northeast India: Meghalaya, Nagaland, Sikkim (Lal *et al.* 2003; Lansdown *et al.* 2013).
Present status: Least Concern (LC) ver 3.1.

3.12. *Utricularia pubescens* Sm.: A small to medium sized herbaceous annual plant growing on soil as well as on wet rocks.
Distribution in northeast India: Meghalaya (Rao & Joseph 1967).
Present status: Reported only once from the area (*v.s.*). Seems to be rare, as it is known from only one more locality in India, *i.e.* Rajpur, near Dehradun (Saxena 1965).

3.13. *Utricularia recta* P. Taylor (*U. scandens* subsp. *firmula* (Oliver) Z. Yu Li)**:** Small herb, growing in grassland as well as on rocks.
Distribution in northeast India: NE India (Li & Cheek 2011).
Present status: Widespread in Africa and Asia**.** In India in the Himalayan part of Uttarakhand (Kumaun), in Sikkim and in Meghalaya (Khasi Hills), and widespread in Nepal and Bhutan; in China only known from western Yunnan (Taylor 1989).

3.14. *Utricularia subulata* L.: An annual to perennial terrestrial plant.
Distribution in northeast India: Jarain, Meghalaya (Joseph & Mani 1982, misidentified as *U. stanfieldii*, an African species that is not known from India, *cf.* Taylor 1989).
Present status: Widespread and common in India.

3.15. *Utricularia inflexa* Forssk.: Medium to large sized suspended aquatic with a whorl of 5-10 floats near the base of the peduncle, corolla white with violet nerves.
Distribution in northeast India: Assam (Taylor 1989).
Present status: Widespread throughout India.

3.16. *Utricularia stellaris* L. f.: Medium to large sized suspended aquatic with a whorl of 3-8 floats above the middle of the peduncle, corolla yellow.
Distribution in northeast India: Meghalaya (Joseph & Joseph 1986; Taylor 1989).
Present status: Widespread.

4. *Pinguicula alpina* L. (Lentibulariaceae): Also known as alpine butterwort, it is a small, herbaceous, perennial insectivore and has white personate spurred flowers, some with a yellow palate.
Distribution in northeast India: Sikkim (Singh & Sanjappa 2011).
Present status: Widespread in alpine region of the Himalaya.

5. *Aldrovanda vesiculosa* L. (Droseraceae): A rare, monotypic, rootless, free floating aquatic carnivorous plant (floats just below the water surface).
Distribution in northeast India: Manipur- Imphal (Zaman *et al.* 2011).
Present status: Very rare in northeastern India and only once reported from Imphal by Deb in 1965 (Zaman *et al.* 2011) and since then it never have been collected there nor from other parts of India. The IUCN (IUCN 2013) listed the species as Endangered B2ab (iii, v) ver 3.1 (Cross 2012).

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